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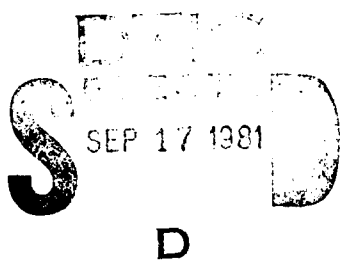

A RAND NOTE

PRELIMINARY EXAMINATION OF AN AUTOMATED, REMOTELY MONITORED, ANTI-ARMOR WEAPON SYSTEM (DEMON)

J. R. Lind

July 1981

N-1652-ARPA

Prepared For

The Defense Advanced Research Projects Agency

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SANTA MONICA, CA. 90406

PREFACE

The Distributed Tank Systems Concepts (Tank Effectiveness Augmentation by Remote Subsystems--TEARS) project, sponsored at Rand by the Tactical Technology Office of the Defense Advanced Research Projects Agency (ARPA), is examining an automated sensor-weapon platform remotely monitored by a tank crew. This subsystem, called Demon, is intended to augment the firepower, firepower mobility, and survivability of tanks. This Note documents the initial set of analytical results that define the engagement effectiveness of Demon in an antitank role.

Computer-simulated firefights between Demons and attacking tanks were compared with firefights where tanks were both defending and attacking. Defense deployments and attack avenues of advance, as developed by a U.S. battalion commander in the Fulda Gap area of The Federal Republic of Germany, were used to examine Demon in a realistic situation. The results showed that tank forces augmented with Demons were able to gain a two- to threefold increase in engagement effectiveness.

SUMMARY

Demon, a sensor-weapon platform remotely monitored by a tank crew, is intended to augment the firepower, firepower mobility, and survivability of current tanks. Operated as a tank-crew-monitored, automated subsystem, Demon allows a tank to engage an advancing enemy without exposing itself. Tanks can initiate engagements at long range using Demon, and later in the attack bring combined main gun and Demon fires to bear. Demon can also be used in an automatic fire mode, while the tank moves to a new position. Additional Demons could be actuated at the new position and the battle resumed.

In this Note we document the initial set of analytical results from our study of the engagement effectiveness of Demon. Firefights between Demons and first tanks in the attack are examined and compared with firefights in which the defense is composed of only tanks. We have used defense deployments and avenues of advance and attack, as developed by a U.S. battalion commander in the Fulda Gap area of Germany, to examine the Demon force in a realistic battle and terrain situation. The Rand TIMER model [1] uses tank positions and advance paths in combination with digitized terrain data to compute ranges to and lengths of paths visible from each defense position. The Rand VISOR model [2] uses derived firing opportunities in combination with operational and weapon data to compute rounds fired, attacker and defender losses, and other engagement-related data.

We have concentrated on one phase of an attack against these defense positions. The attack starts at an initial range of 4 km and

continues until the advancing tanks reach the defense positions. Demon is assumed to have a sensor module with a 0.75 probability of detecting and acquiring targets out to 4 km and homing missiles with a 0.45 single shot probability of stopping an advancing tank. Results are expressed in terms of surviving force fractions, final force ratios, and number of missiles fired by the time the attacker has reached the 2, 1, and 0 km range lines from the defender. The results are presented as a function of the initial force ratio of attackers to defenders.

The relative status of forces when the attack reaches 1 km provides a useful index to the course of the battle. At about 1 km, the attacker must decide whether to press the attack or call for reinforcements. The defender, on the other hand, must decide whether to withdraw or engage the final assault. In the base case (tank-vs-tank), surviving defenders outnumbered surviving attackers at 1 km when the initial force at 4 km was less than about 2:1. When only Demons on defense are firing, the full complement of defender tanks are still in place and the number of remaining Demons equals the number of surviving attacker tanks at initial force ratios of less than about 5:1. Very roughly, then, a defender with Demons could expect to prevail against forces two or three times as large as those which could be handled by tanks alone. If confronted with Demons on defense, the attacker could be confident of success only if initial force ratios of attacker tanks to defender Demons are greater than about 6:1 (see Fig. 1).

Assuming the attack is continued to the defense position from the 1 km line, defender tanks outnumber attacker tanks that reach the position when initial force ratios are 2:1 or less. When Demons fire from the

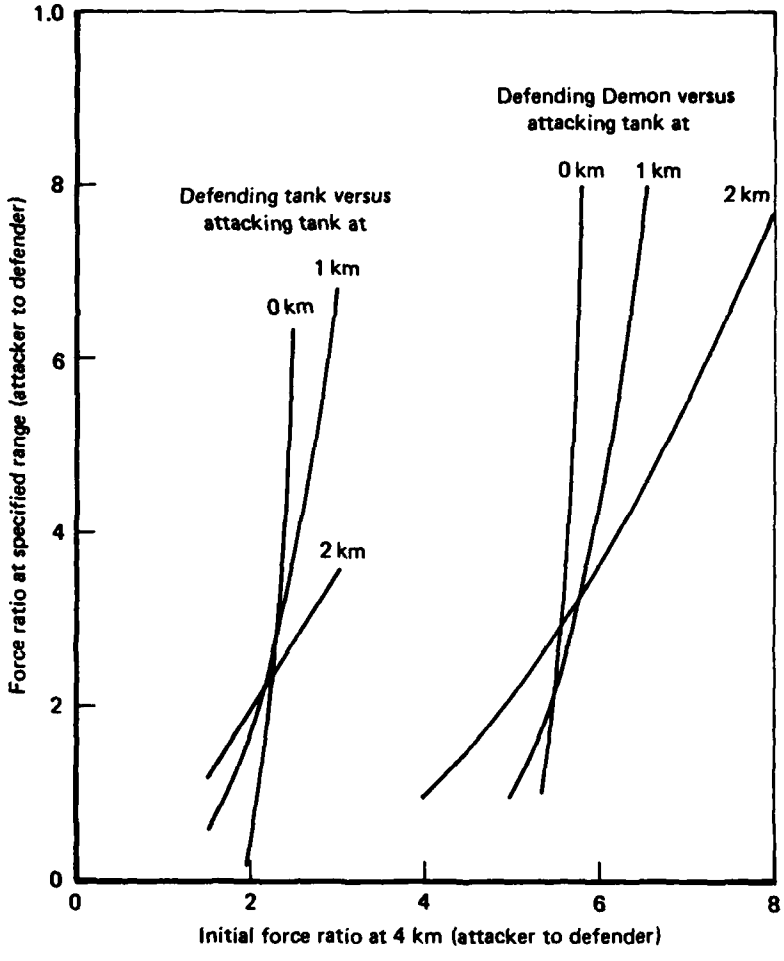

Fig. 1 — Force ratios at 0, 1, 2 km closing from 4 km

defense position, surviving Demons (no defender tanks firing) outnumber attacker tanks that reach the position, at initial force ratios less than about 5.5:1.

Defender forces augmented with Demon could be expected to withstand assaults for initial force ratios greater than 6:1, assuming Demon lives up to its engagement effectiveness estimates. With only tanks on defense, a defender can be expected to withstand assaults for initial force ratios that are less than 2 or 3:1.

This initial look at Demon suggests that to be successful in firefights an enemy may be forced to consider alternative attack tactics, exploit vulnerabilities in the Demon concept, or both. We plan to examine such alternatives in terms of Demon performance in combined arms firefights as a way of defining attractive operational capability envelopes for TEARS.

CONTENTS

I. INTRODUCTION

The Distributed Tank Systems Concept (Tank Effectiveness Augmentation by Remote Subsystems--TEARS) project for the Tactical Technology Office of the Defense Advanced Research Projects Agency (ARPA) is a study of a generic automated ground-to-ground combat system for increasing the firepower of tanks and other combat vehicles. The automated and remotely monitored ground-to-ground combat system is postulated to consist of a missile launching platform (vehicle, missiles, and onboard target search sensors), a command vehicle, and a communications link between the mobile launch platform and the command vehicle. The purpose of the project is to explore the potential advantages of a TEARS system, provide design guidance for test vehicles, and examine the evolution of a prototype TEARS system.

Demon is the name for a remotely monitored target detection and engagement subsystem to augment tanks. Its operation is not limited to tanks--it could be employed by any command element (mounted or unmounted) having the required equipment. Demons are assumed to have onboard sensor systems that can detect targets at longer ranges than visual and missiles with target-seeking warheads.

This Note documents the initial analyses of the engagement effectiveness of Demons defending against attacking tanks. The approach is to compare under identical initial conditions the outcome of computer-simulated firefights between Demons controlled by tanks on defense and advancing enemy tanks. Demons are assumed to have better sensor and weapon performance than tanks in these simulations. The

firefights are weapon-system-vs-weapon-system fights rather than combined arms battles.

We have drawn information and computer programs from other Rand studies to examine Demon in a realistic scenario. Rand developed an intervisibililty model known as TIMER (see Ref. 1) while working with the U.S. Army V Corps staff in Europe a few years ago. This computerized model can determine ranges at which lines of sight exist between defense positions and specific positions on avenues of advance. A second, unpublished model, VISOR, was devised to take the next step--computation of exchanges of fires when lines of sight between attacking vehicles and defense weapon systems are specified by TIMER data (see Ref. 2).

We have considered the firefight results for tank-vs-tank as approximately representing today's tank system capabilities, and Demon-vs-tank outcomes as representing possible future capabilities.

We computed the surviving force fractions, exchange ratios, and average number of weapons fired per vehicle as functions of initial attacker to defender force ratios. A building block approach was used to examine segments of firefights to obtain insight into the comparison of Demon with tanks on defense at each step of the fight. These results are developed for (1) an attacker approaching from ranges of 4 km to 2 km; (2) approaching from 2 km to 1 km; and (3) approaching from 1 km to the defense position. The results of each segment are used as inputs to the next segment to develop the results of an attack advance from 4 km to 1 km and an attack from 4 km to the defense position. With these results as a basis, we then outline deductions, issues, and possible future work.

II. MODELS AND ASSUMPTIONS

DESIGN OF EXPERIMENT

In this first examination of the potential of a generic Demon we want to compare the performance of Demons on defense with the performance of tanks on defense when attacked by enemy tanks. We will develop the details of firefights starting with a series of initial force ratios at several different ranges. Computer runs have been made for three segments of the attack: 4 km to 2 km, 2 km to 1 km, and 1 km to the defense position. We develop the force status of the attacker and defender at the end of the segment as functions of the force ratio at the start of the segment for each of these segments. This building block approach gives insight into the comparison of Demons with tanks on defense at each step of the fight. The results at each step are used as inputs to the next step to provide an assessment of the full fight for each starting range.

TIMER MODEL

The Terrain Intervisibility and Movement Evaluation Routine (TIMER) is a computer program that determines line of sight or intervisibility between defense positions and moving targets in specified terrain. The current version uses terrain in the border area between the Federal Republic of Germany and the German Democratic Republic in the U.S. V Corps sector. An area of approximately 2000 sq km is represented. The terrain data base for the area consists of digitalized data obtained

from the Defense Mapping Agency. The data base includes a data point at every 12.5 meters in the area. Elevation to the nearest meter is given for each data point and the point is identified as being in a forest or urban area.

This relatively fine-grain data base and the TIMER program permits the user to specify one or more defense positions and locations down to the level of individual vehicles or more specific targets. The program determines whether a line of sight exists between each defense position and the targets (see Ref. 1).

Figure 2 shows a deployment of defense position areas for a battalion sized U.S. force in the Fulda Gap area of Germany. These areas include positions for tanks and TOWs. The deployment was created by a battalion commander of the U.S. V Corps on the basis of ten possible routes the enemy might use in advancing on the battalion area.

This combat scenario, used with fine-grain digitized terrain data, was processed in the TIMER model to obtain ranges to 25-meter road segments that could be seen from each defense position. A trace along a road from a defense position presents a series of "see" and "hidden" locations (Fig. 3). The TIMER results have been tabled in computer usable form.

VISOR MODEL

The Fire Visual Strike Opportunity Recorder Model (VISOR) was developed for the next step--exchanges of fires between defender and attacker as the attacker advances along one or more routes. Vehicles advancing in column come into and pass out of view as they advance along

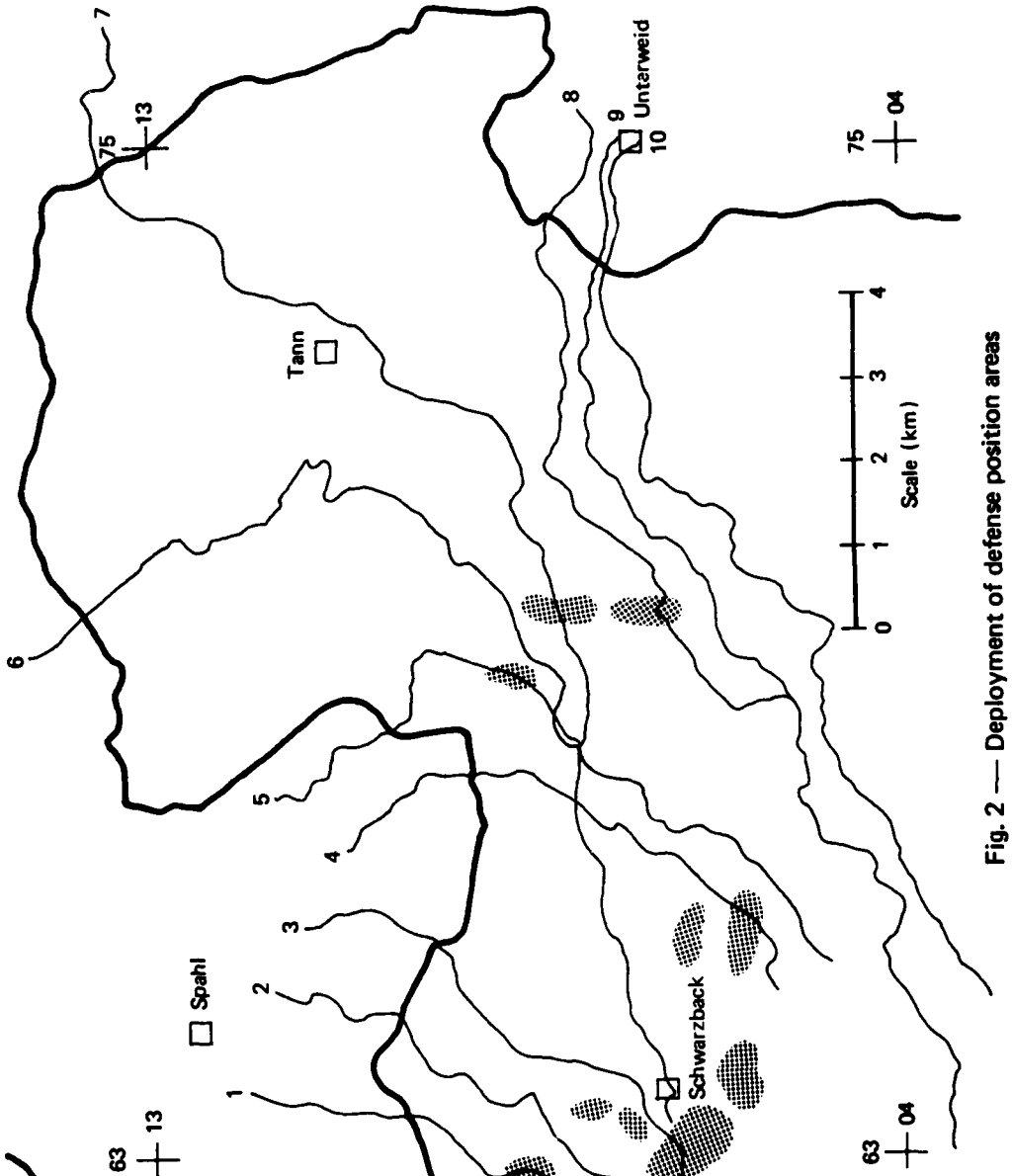

Fig. 2 — Deployment of defense position areas

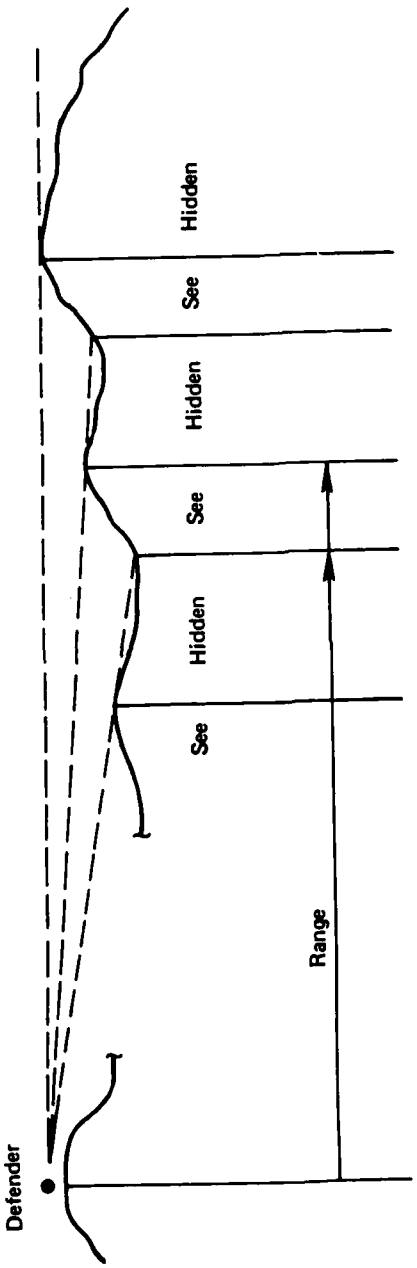

Fig. 3 — TIMER results

these routes. The TIMER route segment data are used as VISOR inputs. Detection times and probabilities, as well as kill probabilities as functions of range, are used to compute the expected kills of attackers and defenders. Kills, after correction for overkills, are recorded for each firing position.

The sequence of events in VISOR is illustrated in Fig. 4. The defender detects the presence of an attacker vehicle as it comes in view with probability Pd following a specified search time. The defender then fires at the target. Target kill is computed if the target stays in view during the flight time of the fired round. The attacker, however, detects the signature of the defender's fire with probability Pd during a specified search time. If an attacker retains a line of sight to the defender, he fires at the defender. The defender may disappear behind cover after his first firing and cause the attacker to waste a shot (the defender does not disappear in present cases). The defender and attacker must re-search when a defender reappears. VISOR computes the many-on-many case when attacker and/or defender have several targets in view. Once a target is in view, a firer may continue to fire, after reloading, at that target and others that come into view. Search must be reinitiated after all targets disappear from view.

VISOR allows the user to control inputs which reflect weapon and sensor performance and other operational parameters independently for each side. Several sensor-weapon systems can be used by each side, so mixed ground attack forces can be considered. Table 1 summarizes the parameters that are user controlled and those assumed for this analysis.

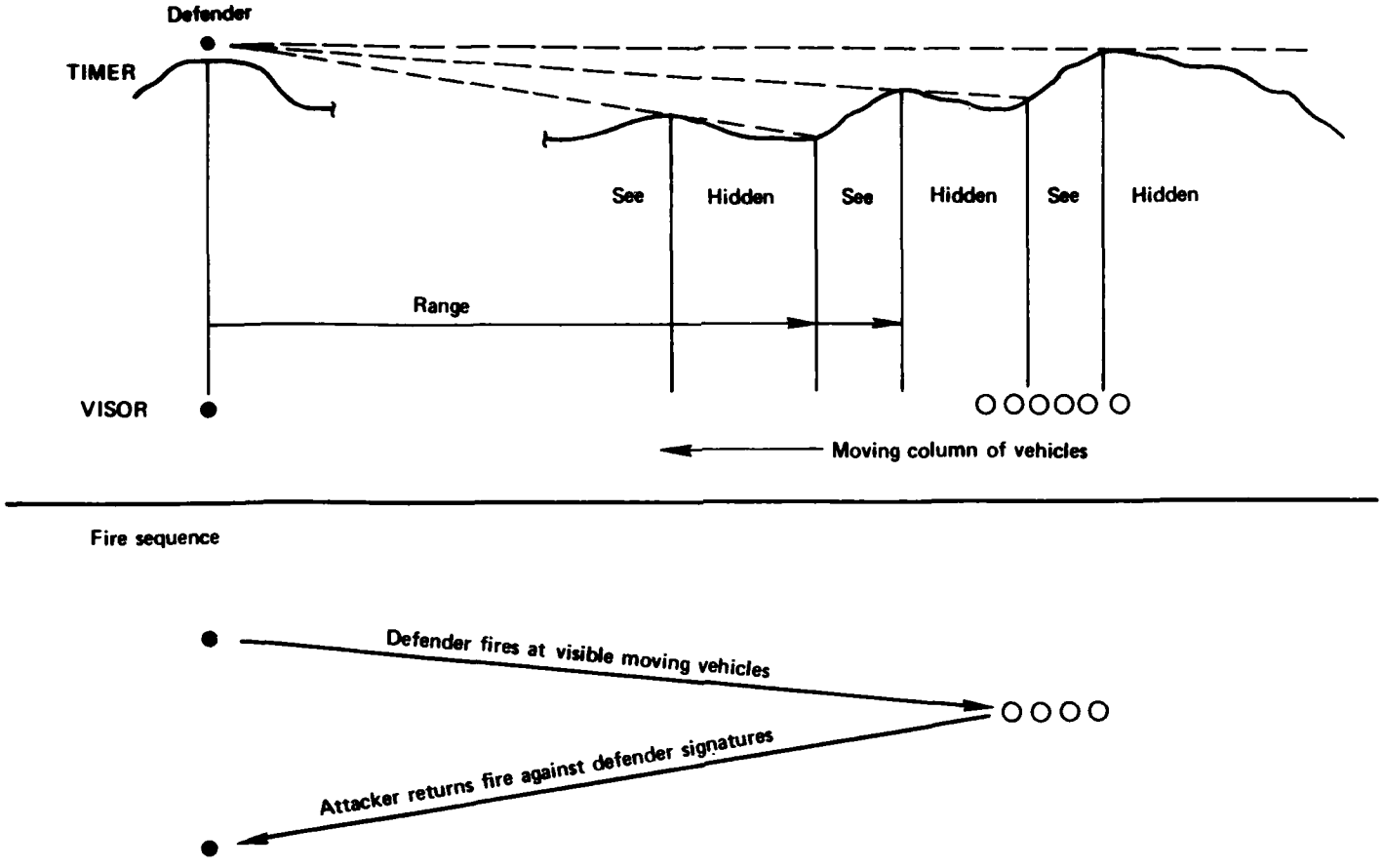

Fig. 4 — VISOR results

Table 1

VISOR PARAMETER SUMMARY

Parameter	Values
Weapon	
Probability of kill as function of range	Table 2
Warhead velocity (average)	Table 2
Reload time	Table 2
Sensor	
Probability of target detection as function of range	Table 2
Search time to detect	Table 2
Operational	
Defender	
Firing doctrine (number rounds fired before disappearing, time hidden between firing sets)	1,0
Total rounds carried per vehicle	50
Disengagement range (between attacker and defender)	0
Unit fraction casualties for disengagement	1.0
Attacker	
Firing doctrine	1,0
Rounds carried per vehicle	50
Vehicles on road	variable
Vehicle spacing (meters)	30
Vehicle velocity (km/hr)	14
Start time along road	0
Unit fraction casualties for disengagement	1.0

WEAPON-SENSOR ASSUMPTIONS

We examined tanks in defense positions opposed by tanks attacking along an avenue of advance as a base case. The first excursion replaces the defending tanks with Demons which have improved sensor and weapon capabilities compared with tanks. Otherwise, Demons operate like tanks. Table 2 summarizes assumed sensor-weapon characteristics.

The tank weapon Pk's are different for the defender and the attacker. The probability of kill given a hit is assumed to be high for

Table 2

TANK AND DEMON SENSOR-WEAPON CHARACTERISTICS

	Sensor					Weapon					
Weapn System	Max. Range (km)	Pd 0-1	Pd 1-2	Pd 2-4	Search Time (sec)	Max. Range (km)	Pk 0-1.5	Pk 1.5-3.0	Pk 3-4	Reload Time (sec)	Muzzle Velocity (kps)
Tank											
Defend	4.0	1.0	0.5	0.2	20	3.0	0.35	0.35	0	25	1.0
Attack	4.0	1.0	0.55	0.2	20	3.0	0.35	0.045	0	25	1.0
Demon	4.0	1.0	0.75	0.75	20	4.0	0.45	0.45	0.45	25	1.0

tank and Demon fires (Pk = 0.8 to 0.9). The probability of hit given a firing degrades, however, when the weapon is aimed at a moving target or at the signature (smoke, flash, etc.) of a weapon that has fired.

We assume that the defender shoots at visible moving targets and have increased the target aim error by one mil for this situation. Attacking tanks stop and fire at the smoke, dust, or flash signatures of firings by defending hulldown tanks or Demons. Aiming error for firing against target signatures is assumed to be about 6.6 meters and independent of range.

While there is a paucity of combat data regarding the aiming errors of tank fire in combat, we assumed that increasing the standard deviation of aiming errors developed in field tests by a factor or decreasing the overall Pk by some factor can approximate combat values.

We assumed further that (1) the standard deviation of aim error for combat is twice the aim error derived from field tests and (2) main tank guns fire at detected targets at ranges less than 3 km.

The weapon fired by Demon is assumed to be a terminal homing weapon with a probability of kill (given launch) of 0.45 independent of range. The maximum firing range for missiles is assumed to be 4 km.

Firing time enters the calculations in two ways: (1) time to search for an initial detection and fire a round and (2) time to reload. Once a target emerges from cover or its firing signature is detected, it is assumed that 20 sec elapse before the first shot is fired. Subsequent shots (reload, re-aim, slew, etc.) occur at 25 sec intervals.

Tank crews visually detect targets with an assumed probability Pd during a 20 sec search time. The probability of detecting a target in an area increases with search time and reaches a maximum at about 20 sec. Continued search of a particular area without looking at another area does not increase the probability of detecting a target.

Figure 5 illustrates the estimated probability of detecting camouflaged tanks with the unaided eye in Western Europe for the clearest 10 days in July and the worst 10 days in December [3]. It is assumed that tanks are "buttoned up" during a firefight and hence binoculars are not used to search small areas. Attacker tanks are assumed to be moving directly toward the defender so that increases in detection probability due to movement are minimized. We have assumed the more optimistic probability of detection for visual target detection shown in Fig. 5.

A Demon would employ advanced electronic or heat sensors, enabling tank crews to detect targets with high probabilities at longer ranges. We assumed a 0.75 detection probability at 4 km. This estimate is based on purposeful degradations of some current test results.

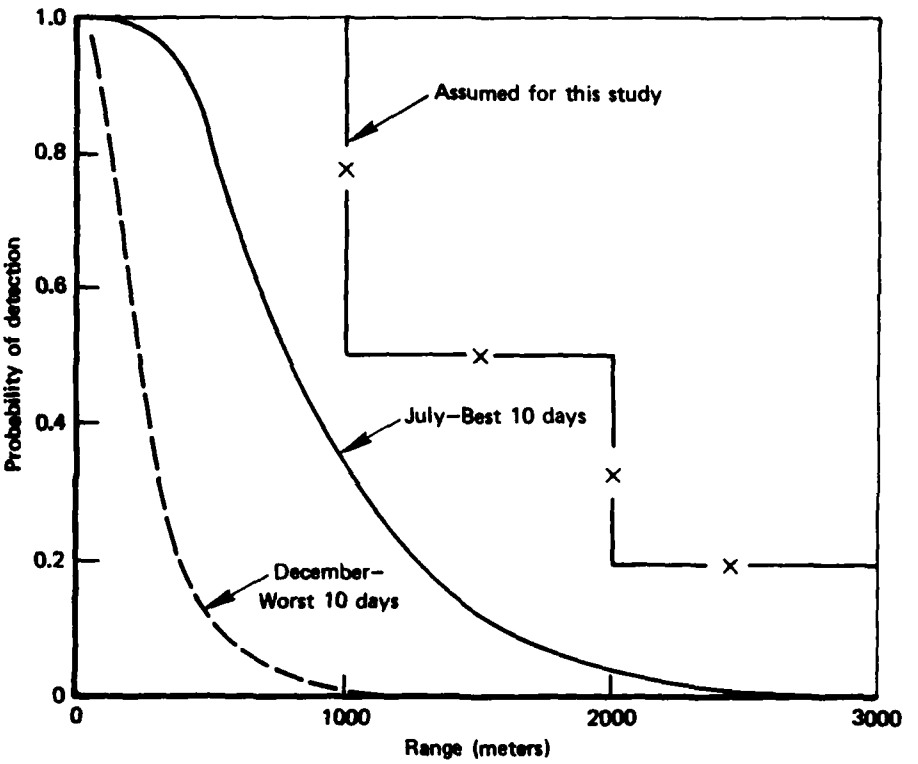

Fig. 5 — Probability of detecting a camouflaged tank
(Western Germany, unaided eyeball)

ATTACKER APPROACH

The defense positions developed by the U.S. Army V Corps unit commander are arranged so that some weapon systems (tank, TOW, etc.) command views of possible advance routes at distant ranges. Others oversee routes at shorter ranges. In addition, weapons are initially arranged so that the most probable advance routes are most heavily defended. The battalion is then deployed to defend against an attack that advances along one or more routes.

Battalion defenses include 45 positions occupied by tanks, 10 positions occupied by TOWs, and 18 occupied by Dragons. The attacking force may advance along one or more of 10 advance routes. Many long computer runs are required to assess results when all weapons fire during an attack. We chose one of the tank positions and developed a composite road from the road segments that can be seen from that position to simplify our initial look at Demon. Hence, we have a single defended position and a single attack route along which an enemy force advances. Although this is a restricted sample, it is sufficient for a first cut assessment of the Demon potential. A fuller examination of Demon in a force-on-force fight may be made later in the study.

Attacking tanks are assumed to advance along a road (not necessarily on the road) in column. The column moves at a constant 14 km/hr speed and a spacing of 30 meters between tanks. At 1 km from the defender, the attacking column of tanks deploys (line abreast) in an area not visible to the defender and all surviving tanks assault the defense position simultaneously.

FORCE RATIO

In this Note, analytical results are presented as functions of the attacker to defender force ratios at the start of the segment of attack being examined. For example, results are presented as functions of the force ratio at 2 km assuming the 2 km to 1 km segment is being examined.

The definition of a force ratio is straightforward in the base case where attacker tanks confront defender tanks. However, the definition of a force ratio becomes clouded when remote sensor-weapon platforms are under direct management of a tank or other command vehicle. With one Demon being controlled by one tank, the defender has two firing platforms per tank--the tank main gun and the Demon weapon. With two Demons, each with half the rounds of a single Demon that could fire for the full firefight, there are three platforms per tank but a capability equivalent to one Demon and one tank. Since there are many variations of the number of firing platforms per command vehicle, we adopted a convention that defines the number of defenders, for force ratio purposes, as the number of command vehicles in the unit.

In this document we examine firefights in which one Demon or one tank is on defense. The defender is attacked by the number of tanks defined by the initial force ratio (e.g., for an initial force of 4:1, four attacking tanks advance against one defender).

III. RESULTS

We summarize the results for the tank-vs-tank and Demon-vs-tank cases in five parts: (1) the longer range phase of the attack in which the advance starts at 4 km and closes to 2 km; (2) the intermediate range phase of the attack, from 2 km to 1 km; (3) the final phase of the attack, from 1 km to the defense position; (4) the combined long and intermediate parts (summarizing the attack from 4 km to 1 km); and (5) all three parts combined to summarize the full attack from 4 km to 0 km.

LONGER RANGE FIRES--4 km CLOSING TO 2 km (Figs. 6-10)

Fraction Killed and Surviving

Figure 6 summarizes the fraction of each force killed during the 4 km to 2 km advance as a function of initial force ratio. Note that less than 5 percent of attackers are killed when tank engages tank (low detection probability and low kill probability at these ranges). In the tank-vs-tank case, the effect of mass makes itself felt at these longer ranges in the form of more rounds fired by the attacker. Each defender shot is returned by several shots, with the result that the fraction of defenders surviving is rapidly reduced.

When Demon is used, the attacker's fractional casualties are a strong function of the initial force ratio. Demon's higher Pd and Pk at the longer ranges allow more effective defense firings, resulting in high attacker losses.

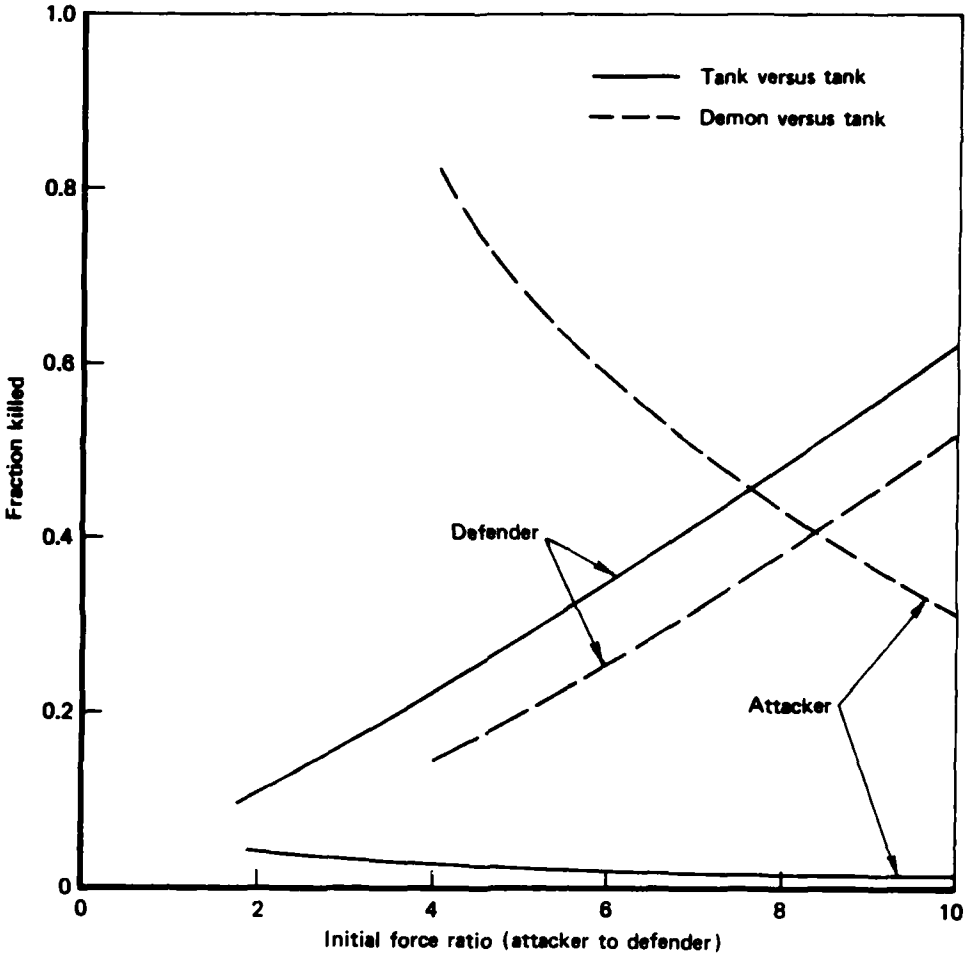

Fig. 6 — Fraction of force killed
(closing from 4 km to 2 km)

Fraction Surviving

Figure 7, in particular, illustrates the changes in force ratio that can occur when a weapon such as Demon is employed by the defense. Using estimates of current tank weapon effectiveness and visual detection, neither side suffers heavy attrition by the time the attack has closed to 2 km. Visual detection probabilities and tank fire accuracy are low at longer ranges, with the result that heavy damage is not sustained by either side.

The status of forces at 2 km is drastically changed when Demon is employed. Demon fires are not returned beyond a range of 3 km, resulting in initial force ratio reductions before the attacker can respond. In addition, the higher Demon detection probability allows Demon to get off more shots as the attacker closes. The attacker force is thus reduced much faster than is the Demon force. At initial force ratios less than about 3.5:1 the attacker force would be annihilated while over 70 percent of the Demons remain. If the attacker were to break off an attack when it lost 70 percent of its force, the attacker could not close if the initial force ratio were less than about 5:1--a much different circumstance than expected with today's forces.

Ending Force Ratio

Figure 8 portrays the force ratio at 2 km as a function of the force ratio at 4 km. The force ratio at 2 km can increase, decrease, or remain the same as the initial force ratio at 4 km. The diagonal line indicates the transition from increasing to decreasing.

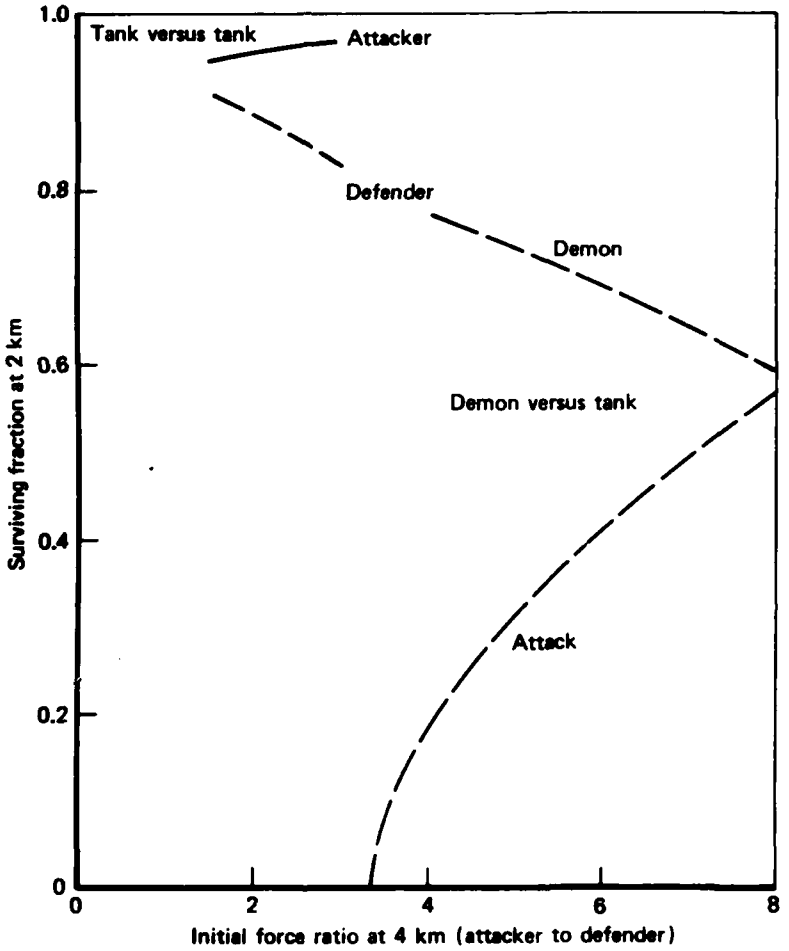

Fig. 7 — Surviving force fraction at 2.0 km
(closing from 4 km to 2 km)

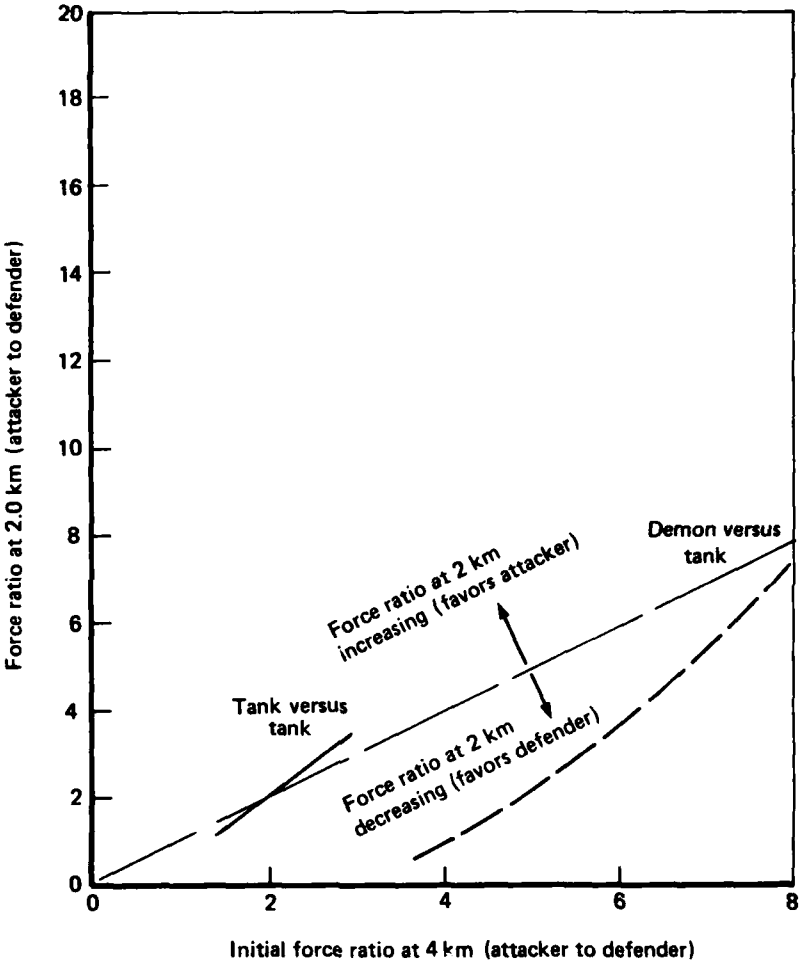

Fig. 8 — Force ratio at 2.0 km
(closing from 4 km to 2 km)

The force ratio at 2 km is reduced from its inital value at 4 km and is favorable to the defense for initial force ratios less than about 2:1 (tank-vs-tank case). The curve of the tank-vs-tank case has been truncated at 3:1 as increasing initial force ratios provide no additional useful information for this analysis.

With Demon on defense, the force ratio at 2 km is reduced from the initial force ratio and is favorable for the defender at initial force ratios less than 8:1.

Exchange Ratios

Exchange ratios (Fig. 9) amplify the previous results. Defending tank forces lose more vehicles than attacking forces at initial force ratios greater than about 1.3:1 at these long firing ranges. On the other hand, Demons extract exchange ratios greater than 8 at initial force ratios of 8:1 or less.

Ammunition Expenditure

Figure 10 summarizes the ammunition expended by each force during the advance from 4 km to 2 km in terms of the ammunition expenditure for the attack per initial vehicle.

Defending tanks fire about 5 rounds per initial defending tank while the attacking tanks fire about 3.5 rounds per initial attacking tank in the tank-vs-tank case (initial force ratios greater than 3:1). At higher force ratios, the defense fires about the same number of rounds (5) while the attacker returns about 4 rounds per attacking tank.

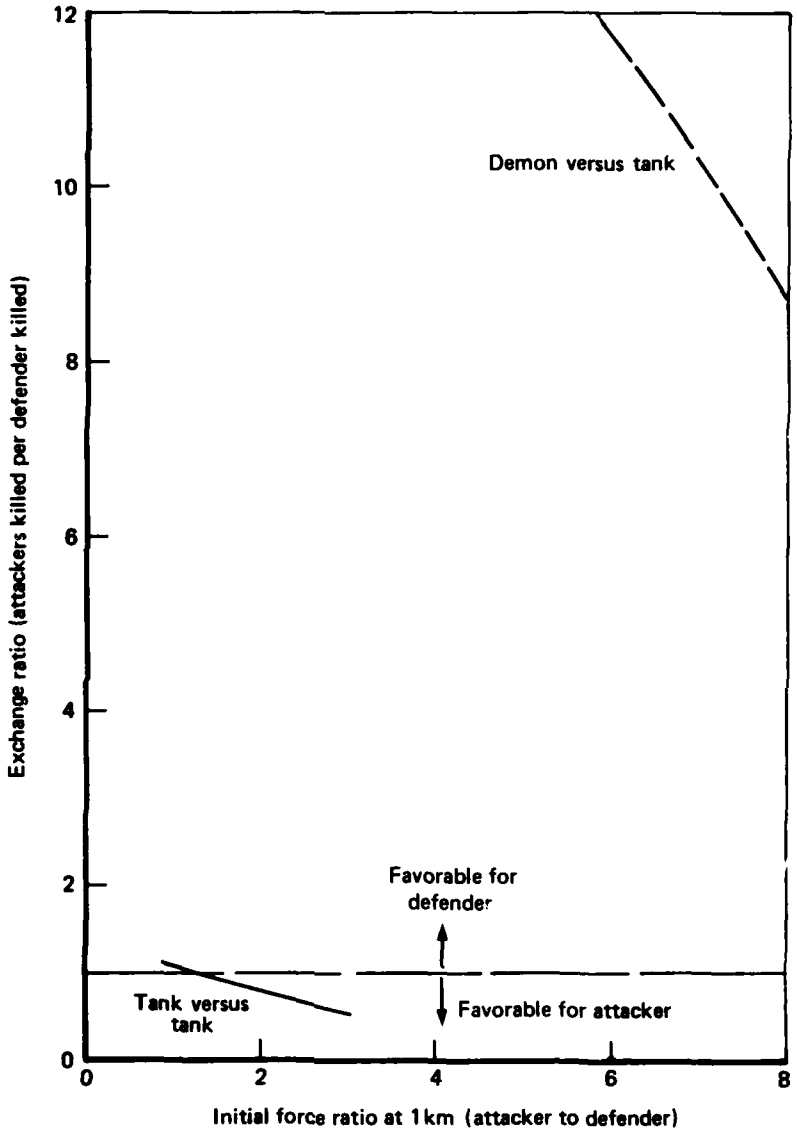

Fig. 9 — Exchange ratio (ATK/DEF)
(closing from 4 km to 2 km)

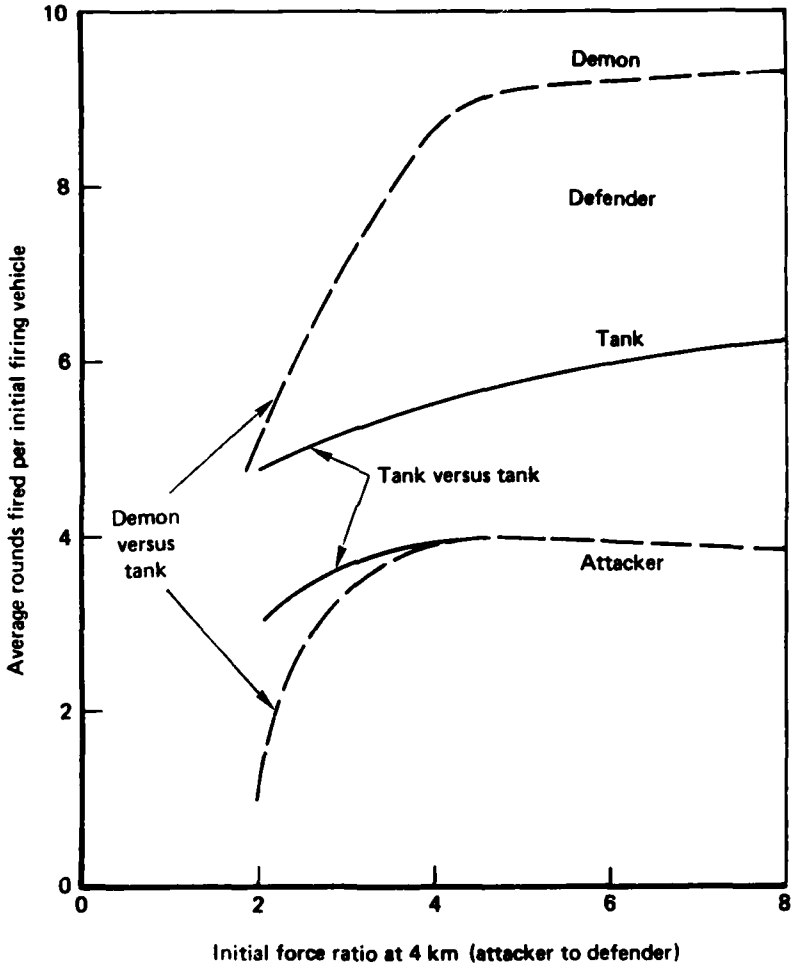

Fig. 10— Average number rounds fired per initial firing vehicle
(closing from 4 km to 2 km)

In the Demon-vs-tank case, for initial force ratios less than about 4:1, the defense fires between 3 and 9 rounds per defending Demon and the attacker fires between 1 and 4 rounds per attacking tank. The rapid change in numbers of rounds fired is produced by Demon running out of targets.

Demon does not run out of targets and fires about 9 rounds per defending Demon at force ratios greater than about 4:1. Attacking tanks fire about 4 rounds per attacking tank.

Demon starts firing at targets at about 4 km because of its capability to detect and fire at targets at this range. The attacker tanks, on the other hand, must absorb the fire until they advance to their maximum firing range of about 3 km. This results in Demon reducing the number of attacking targets and hence the number of attacker rounds that can be fired.

Summary

Figure 8 summarizes the overall changing status of forces as the attacker closes from 4 km to 3 km.

In the tank-vs-tank case, the attacker increases the force ratio for attacks with initial force ratios greater than about 2:1. The defender has the advantage at smaller initial force ratios. With Demon on defense, the defender reduces the force ratio at initial force ratios of less than about 8:1, suggesting that the defense has improved its advantage. An analogy of a defender armed with rifles with telescopic sights (Demon) opposed by an attacker armed with short-range pistols (attacker tanks) is particularly relevant--riflemen outrange the

pistolmen and take their toll before the pistolmen can return fire.

INTERMEDIATE RANGE FIRES--2 km CLOSING TO 1 km (Figs. 11-15)

Assuming the attack starts at 2 km, the fraction of attackers and defenders killed as a function of initial force ratio has the same form as in the previous segment with all curves moved toward smaller initial force ratios (Fig. 11). More attackers than defenders are killed at initial force ratios less than 2:1 for the tank-vs-tank case, and 3.5:1 for the Demon-vs-tank case.

Figure 12 summarizes the force ratio at 1 km as a function of the initial force ratio at 2 km. In the tank-vs-tank case, the force ratio at 1 km increases in the attackers' favor when the initial force ratio is greater than about 2:1; this same result was also developed in the 4 to 2 km case (Fig 8).

In the Demon-vs-tank case, the force ratio at 1 km is in the defenders' favor for initial force ratios at 2 km less than about 3.5:1. The 3.5:1 and below initial force ratio favoring the defender is well below the 8:1 initial force ratio of the 4 to 2 km result (Fig. 8), indicating that Demon performs better at the longer ranges. This reduction in Demon performance occurs because the attacker tanks have a higher probability of detecting and killing Demons at shorter ranges rather than any reduction in Demon capabilities.

The riflemen-pistolmen analogy is also appropriate here (but to a lesser degree). The pistolmen are now within range and can return fire. The greater number of pistolmen firing as compared to riflemen take their toll of riflemen.

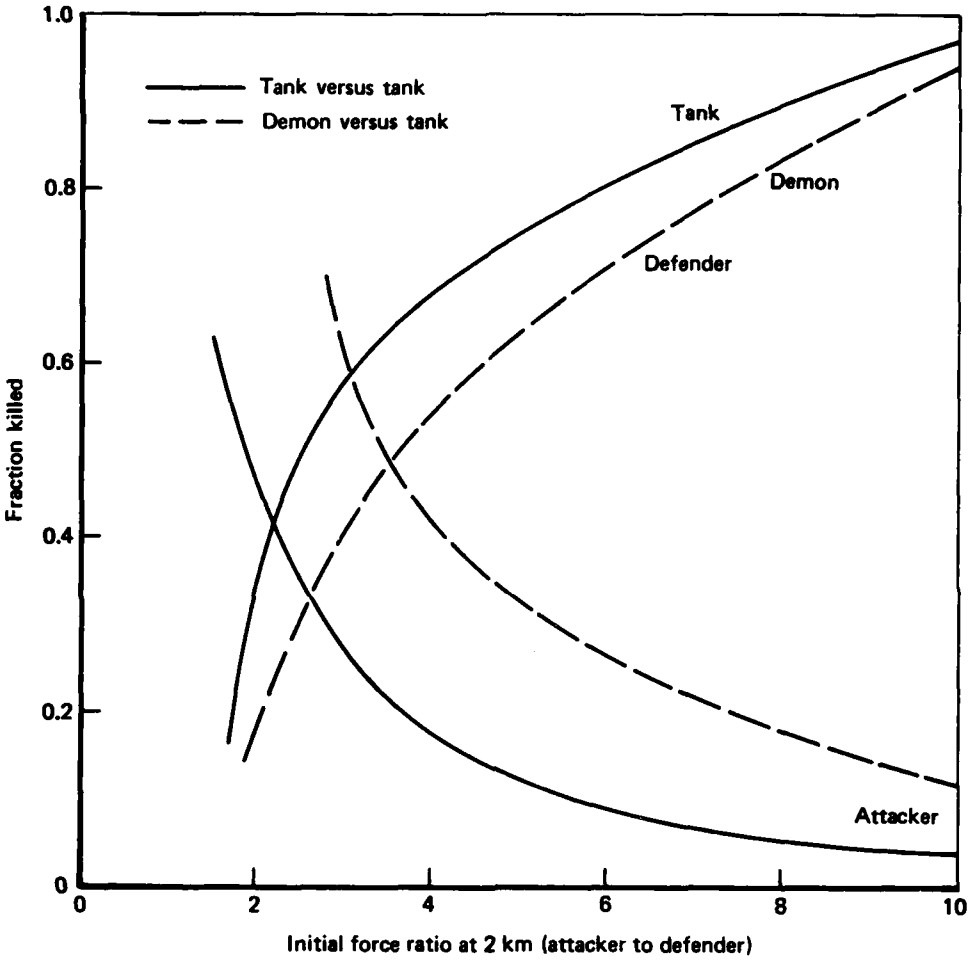

Fig. 11 — Fraction of force killed
(closing from 2 km to 1 km)

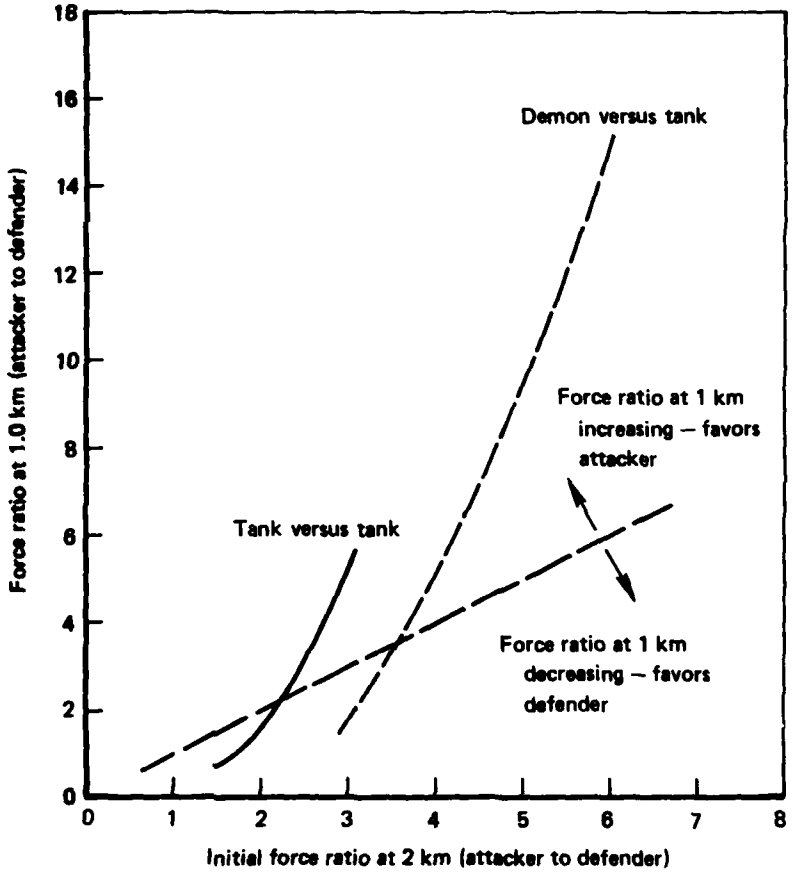

Fig. 12 — Surviving force fraction
(closing from 2 km to 1.0 km)

Figures 13, 14, and 15 amplify the same conclusion by showing, respectively, the effects on force fraction surviving, final force ratios, and exchange ratios.

FINAL ASSAULT FIRES--1 km CLOSING TO 0 km (Figs. 16-19)

In the final phase of the attack, the defender tank and Demon have about the same capabilities (detection probabilities are high, kill probabilities are similar, and cyclic firing rates are the same). There is not much difference in the results. Note the similarity of the curves depicting fraction surviving, force ratio at 0 km, exchange ratio, and average number of rounds fired per initial vehicle (Figs. 16-19).

Demon does slightly better because of its weapon's higher kill probability. Either defender system (Demon or tank) can be successful in reducing the force ratio at 0 km for initial force ratios at 1 km of less than about 2:1 (Fig. 17).

At close ranges, in the riflemen-pistolmen analogy, both sides have about equal single shot kill capabilities, consequently, the side with the greater number of firers prevails.

STATUS OF FORCES--ATTACK CLOSES FROM 4 km TO 1 km (Figs. 20-23)

Combining the attack results for the 4 km to 2 km attack with the 2 km to 1 km attack shows the attack picture before the final assault. The results can be anticipated from the component attacks. For tank vs tank, the fraction of defender forces surviving exceeds the fraction of attacker forces surviving at 1 km only when initial force ratios are

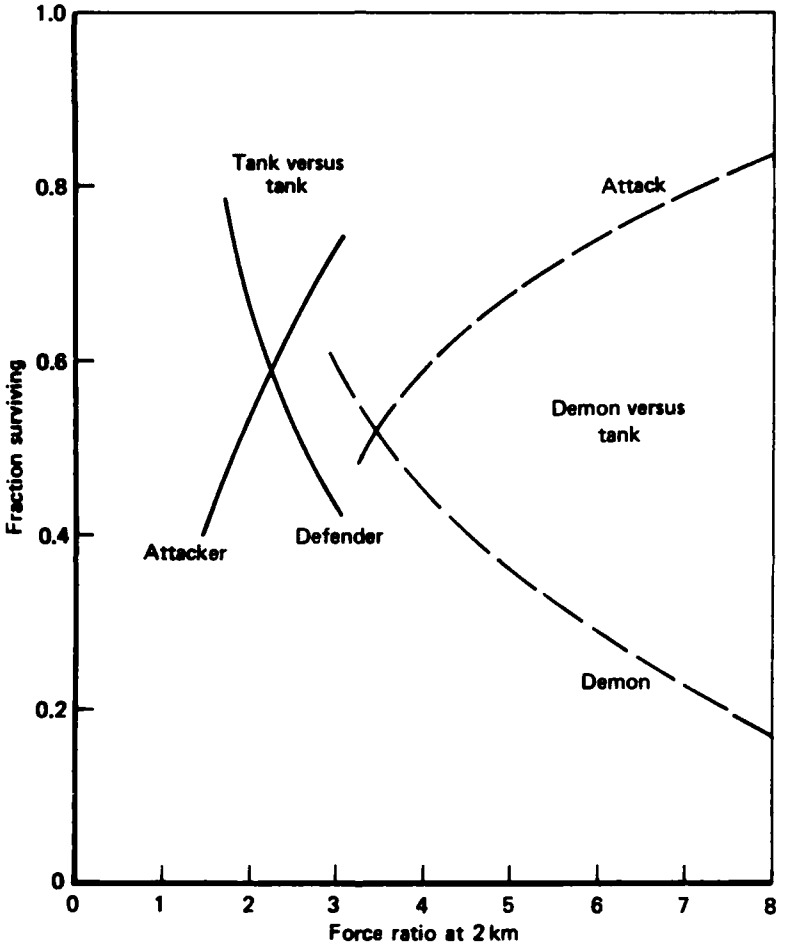

Fig. 13 — Final force ratio
(closing from 2 km to 1.0 km)

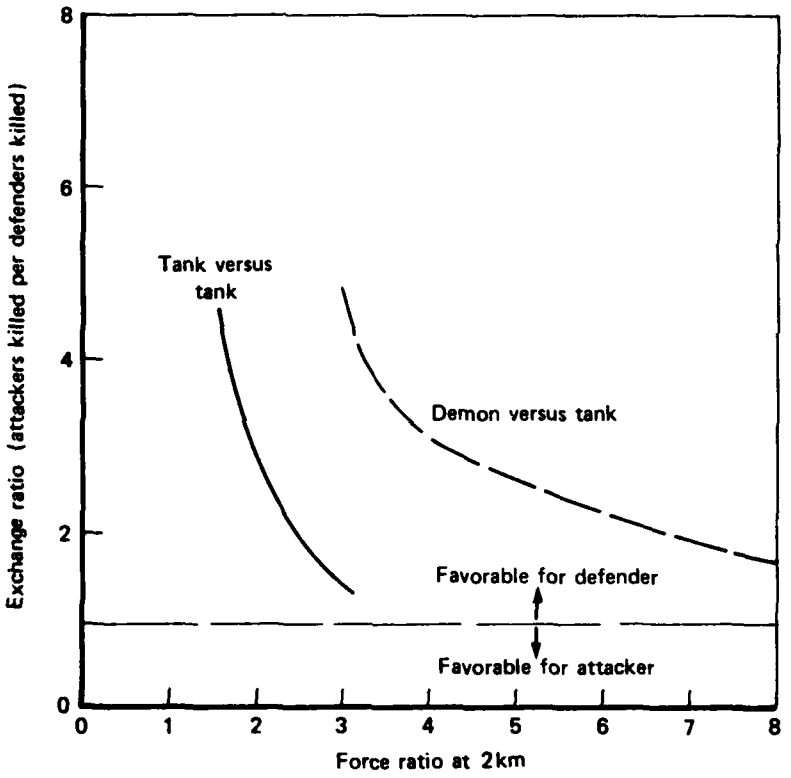

Fig. 14 — Exchange ratio
(closing from 2 km to 1 km)

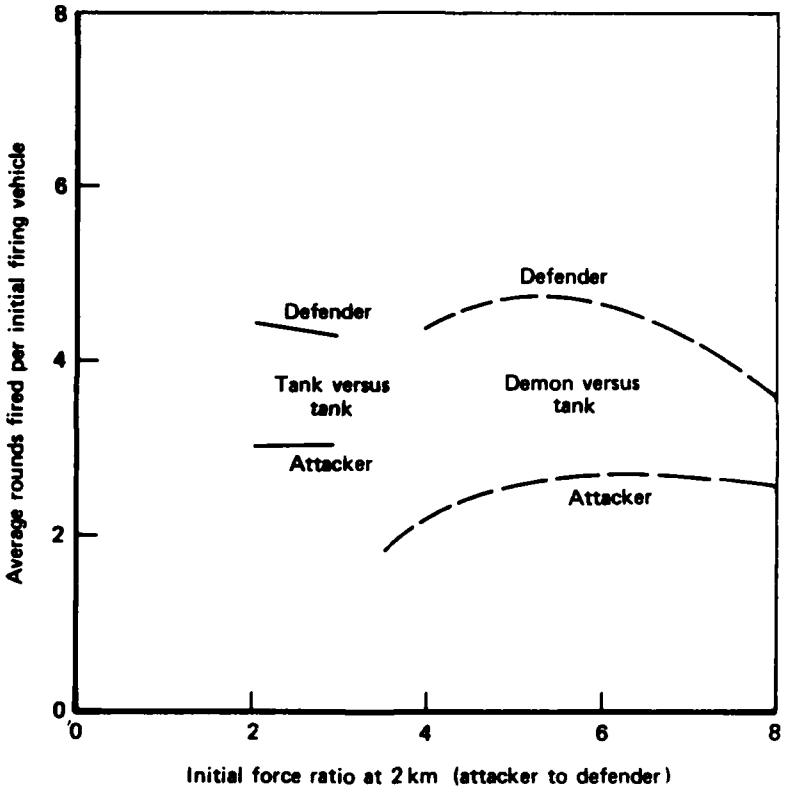

Fig. 15 — Average number rounds fired per initial firing vehicle
(closing from 2 km to 1 km)

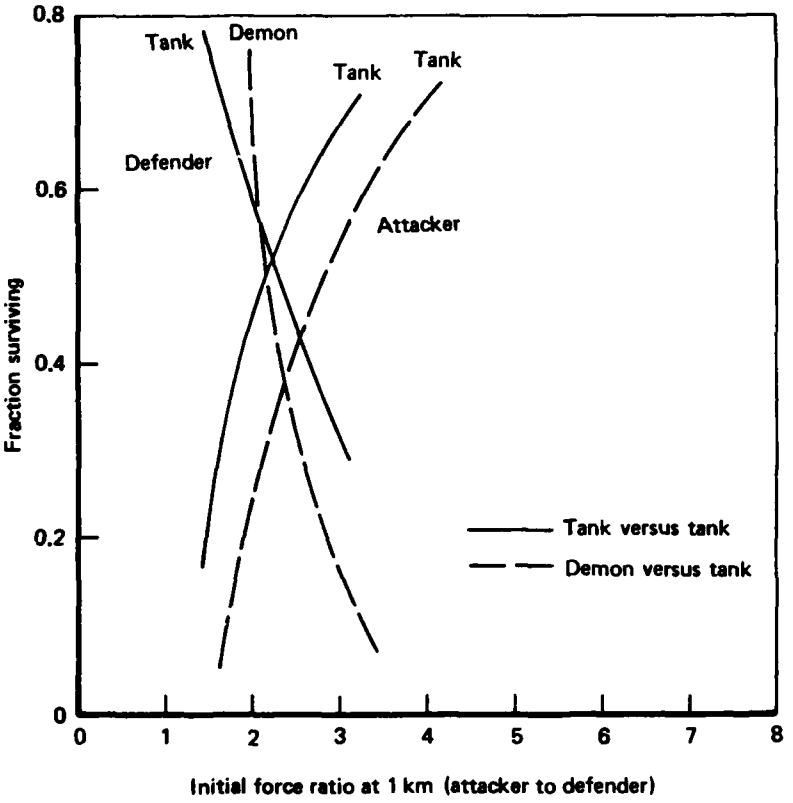

Fig. 16 — Surviving force fraction
(closing from 1 km to 0 km)

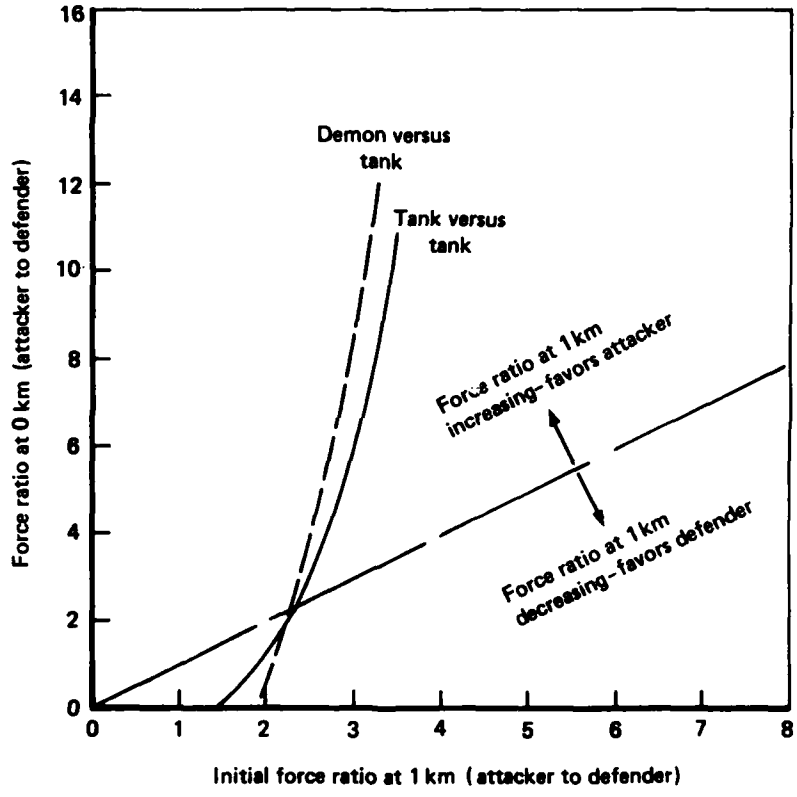

Fig. 17 — Force ratio at 0 km
(closing from 1 km to 0 km)

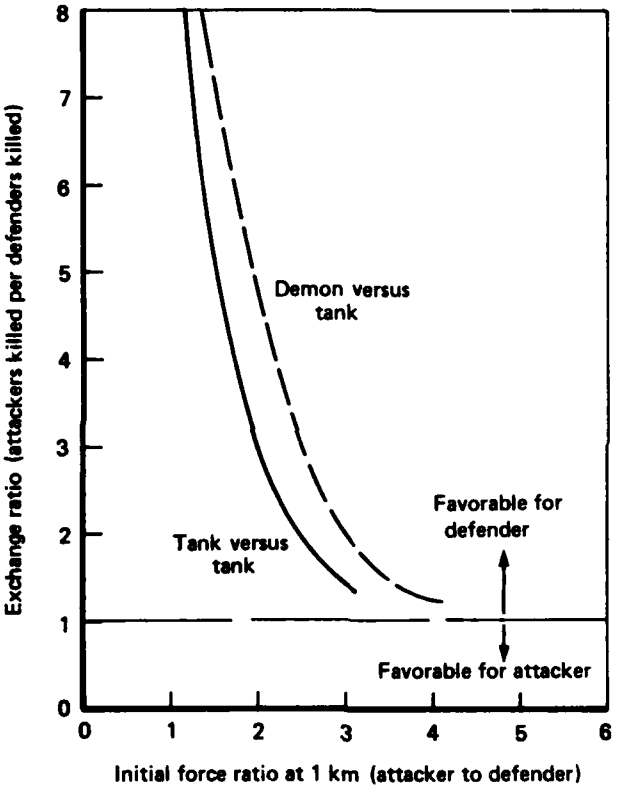

Fig. 18— Exchange ratio
(closing from 1 km to 0 km)

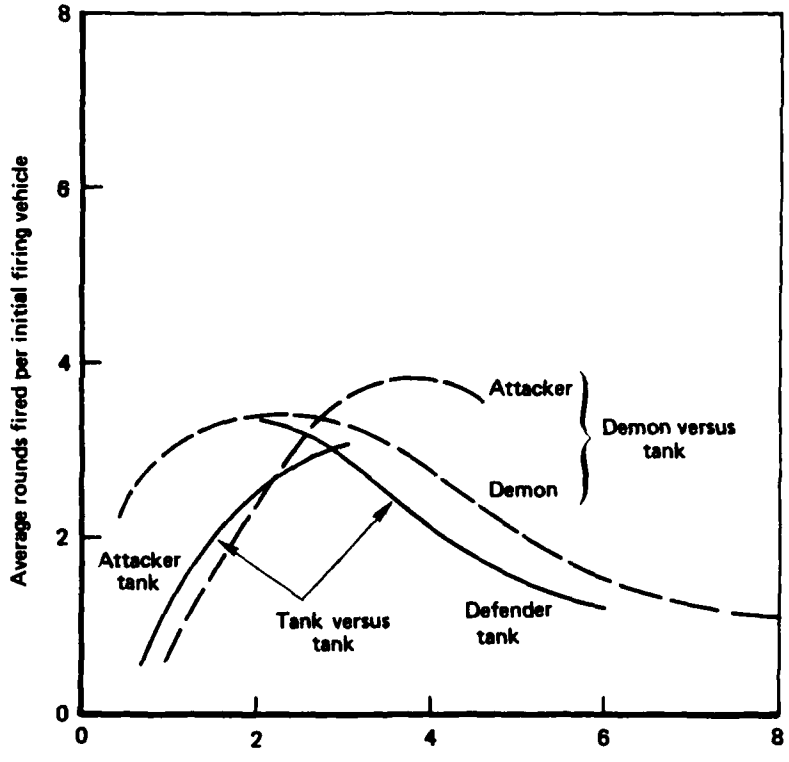

Fig. 19 — Average number rounds fired per initial firing vehicle
(closing from 1 km to 0 km)

less than 2:1 (Figs. 20 and 21).

The exchange ratio (attackers killed per defender killed) is favorable to the defender only at force ratios less than 1.9:1 (Fig. 22).

The average defender fires 9 to 10 rounds. The average attacker returns 6 to 7 rounds (Fig. 23).

The story is different with Demon. At force ratios less than about 4:1, the attacker is annihilated (Figs. 20 and 21). Only about 35 percent of the Demons are lost. If the attacker is assumed to break off at 70 percent casualties, Demon can stop an attack at initial force ratios of less than about 6:1.

Demon has high exchange ratios (>5:1) when initial force ratios are less than about 6:1.

Demon fires between 5 and 14 rounds while the average attacker fires between 1 and 8 rounds, depending upon initial force ratio (Fig. 23).

STATUS OF FORCES--ATTACK CLOSES FROM 4 km TO 0 km

The full attack extends the results for the attacker advance from 4 km to 1 km to the defense position. For the tank-vs-tank case, the fraction of defender forces surviving at the end of the final assault exceeds the fraction of the attacker force surviving when initial force ratios (at 4 km) are about 2.2:1 or less (Fig. 24) as compared with 2:1 or less at one kilometer.

Within the assumptions for this analysis, tanks on defense annihilate the attacking force for initial force ratios of about 2:1 or

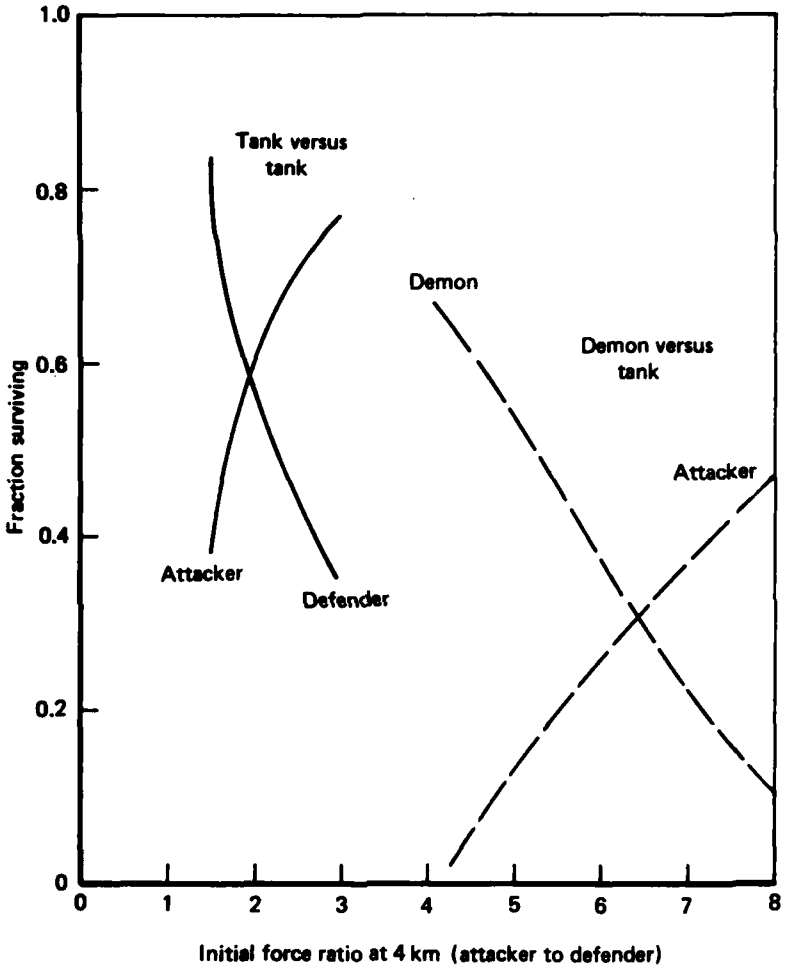

Fig. 20 — Surviving force fraction
(closing from 4 km to 1 km)

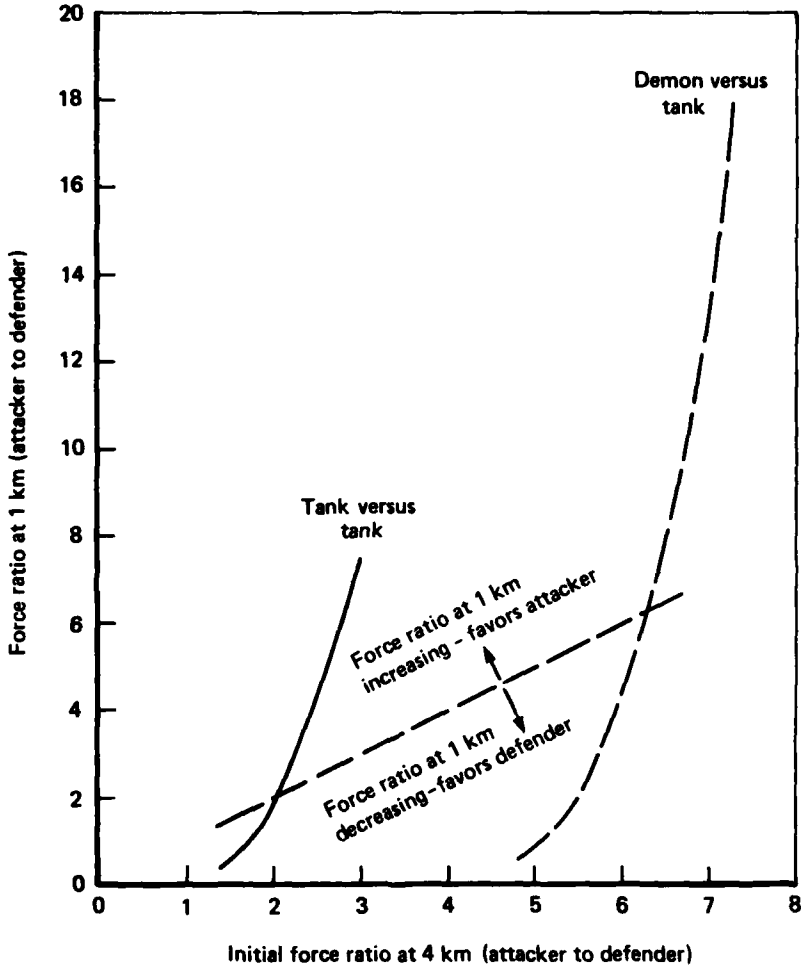

Fig. 21 — Final force ratio
(closing from 4 km to 1 km)

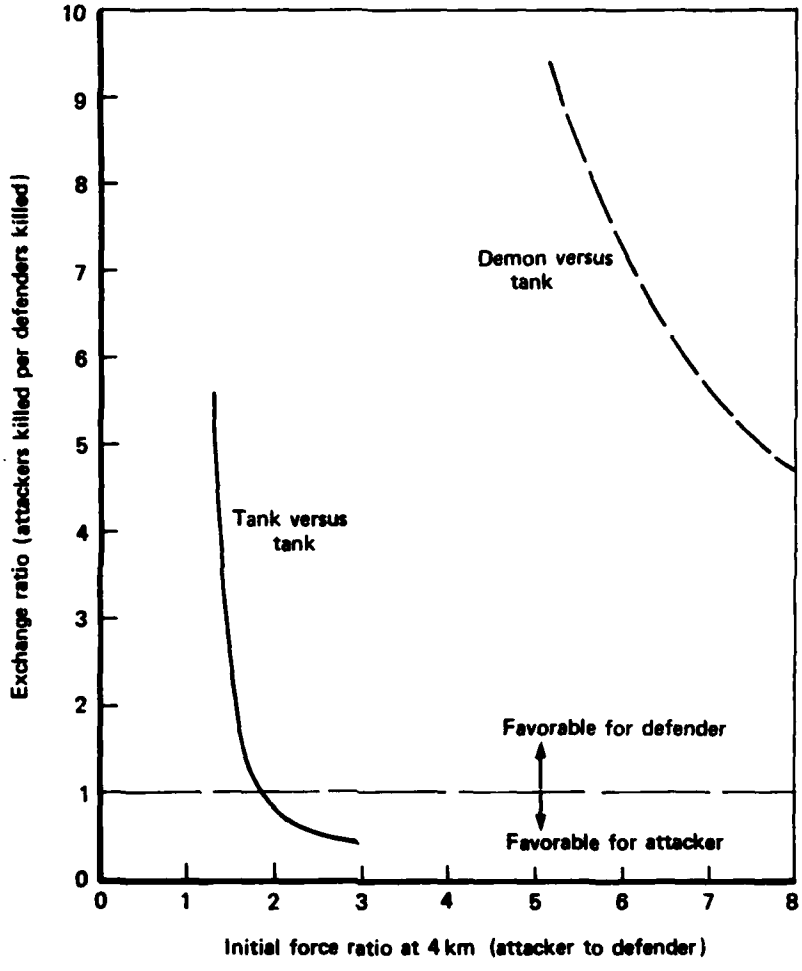

Fig. 22— Exchange ratio
(closing from 4 km to 1 km)

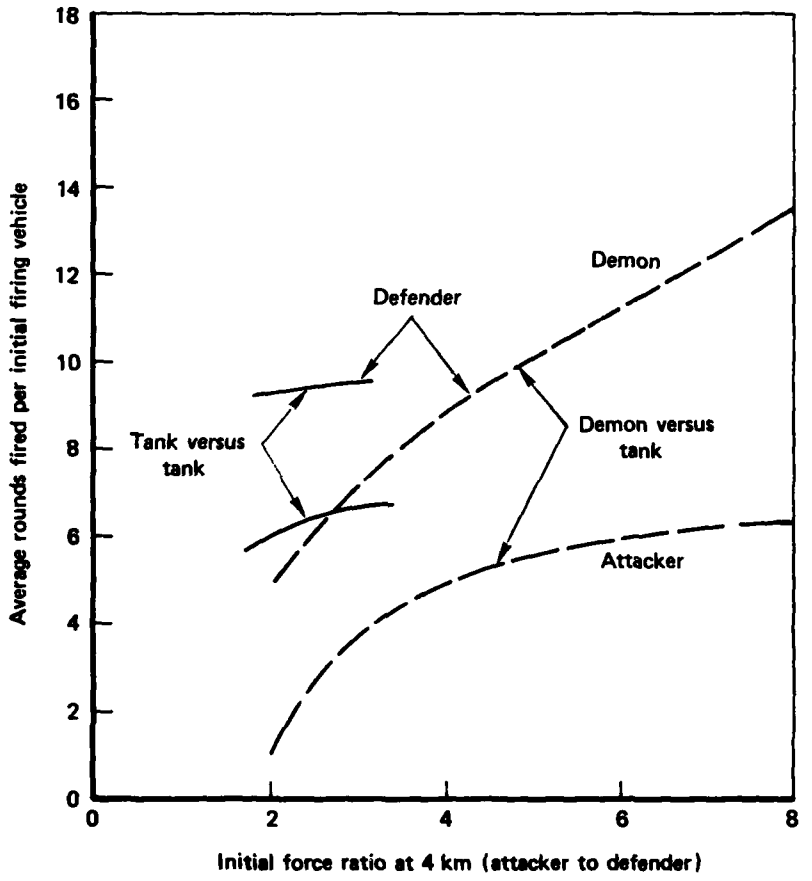

Fig. 23 — Average number rounds fired per initial firing vehicle
(closing from 4 km to 1 km)

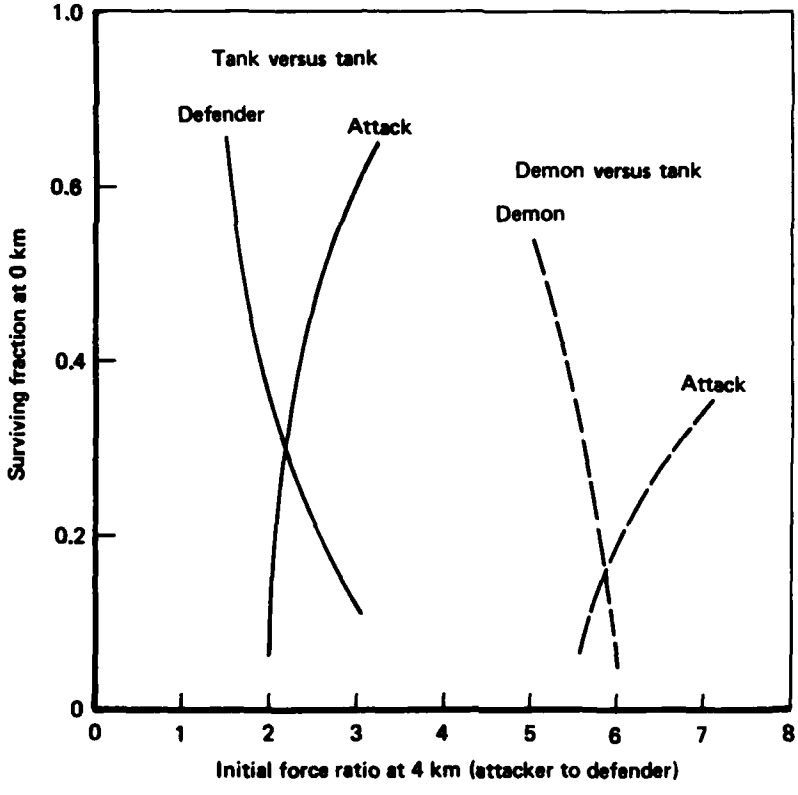

Fig. 24 — Surviving force fraction
(closing from 4 km to 0 km)

less. Demons annihilate the attacking force for initial force ratios of about 5.5:1 or less (Fig. 25).

The exchange ratio (attackers killed per defender killed) is favorable to the defender tank at initial force ratios less than 3.5:1 (Fig. 26) as compared with 1.9:1 or less at one kilometer. The average defender tank fires about 11 rounds and the average attacker tank fires about 8 rounds for an attack when the initial force ratio is about 2:1 (Figs. 27 and 28).

The Demon on defense vs tanks on the attack show very similar changes. The fraction of defender Demons surviving at the end of the final assault exceeds the fraction of the attacker tanks surviving when initial force ratios (4 km) are about 5.5:1 or less.

Demon retains high exchange ratios (>4:1) for the full attack when initial force ratios are 8:1 or less (Fig. 26). The exchange ratio is reduced as compared with the >5:1 at one kilometer. Demon fires an additional 1 to 2 rounds during the final assault for a total of 8 to 14 (Fig. 27).

SUMMARY OF ATTACKS BY PHASES

Figures 29 and 30 provide summary pictures of the survival of attacker and defender forces at 2, 1, and 0 km from the defense position. In the tank-vs-tank case, defender fires kill about equal numbers of attacking tanks between 2 and 1 km as they do between 1 and 0 km (Fig. 29). Demon, on the other hand, produces most of its kills before the attacker closes to 2 km (Fig. 29). Attacker tanks firing against defender tanks produce most of their kills between 2 km and 1

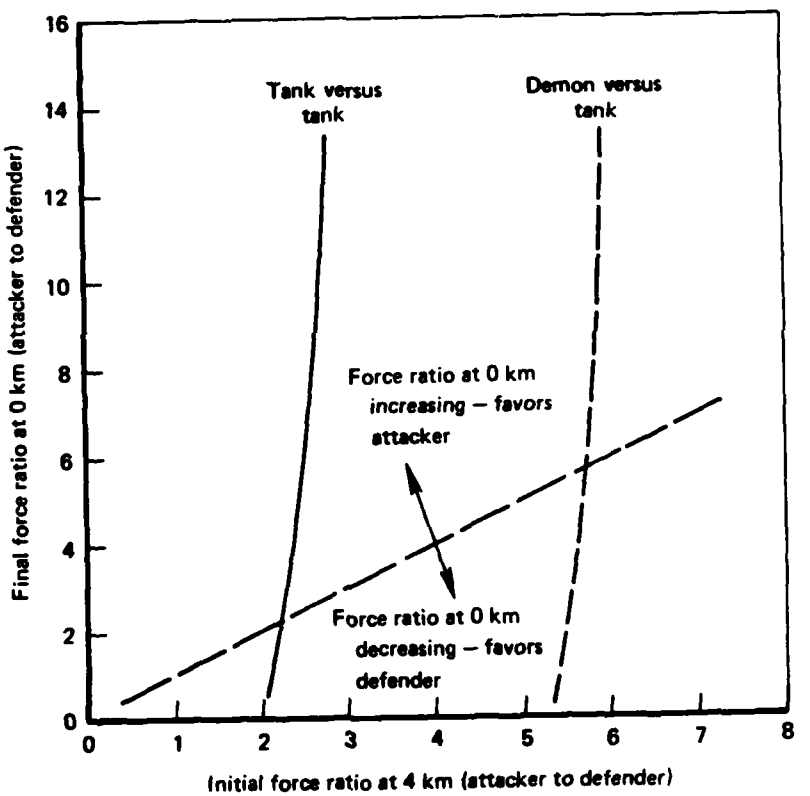

Fig. 25— Force ratio at 0 km
(closing from 4 km to 0 km)

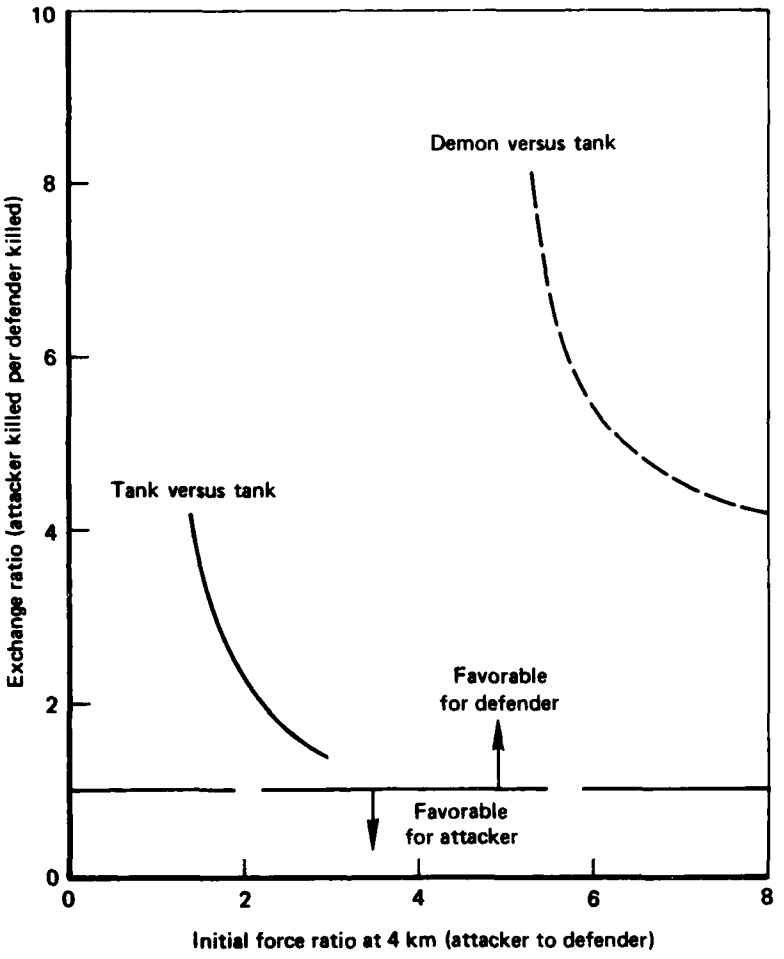

Fig. 26 — Exchange ratio
(closing from 4 km to 0 km)

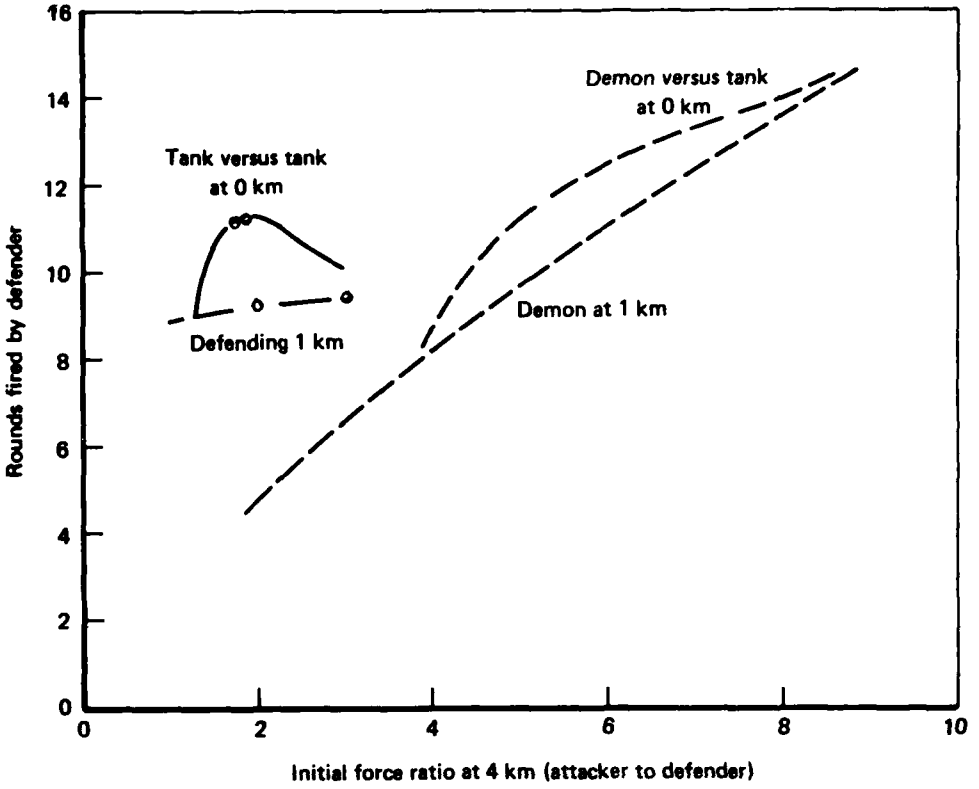

Fig. 27 — Average number rounds fired by defender

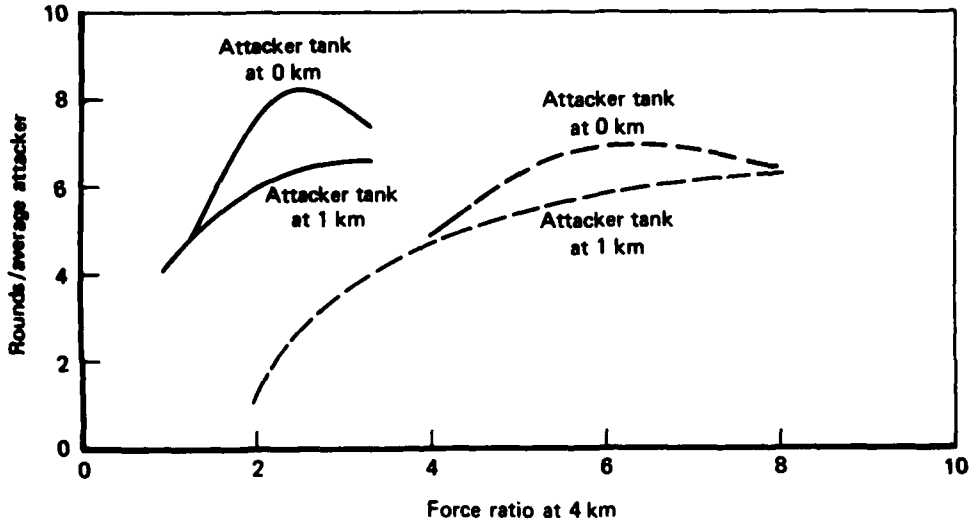

Fig. 28 — Average number rounds fired by attacker

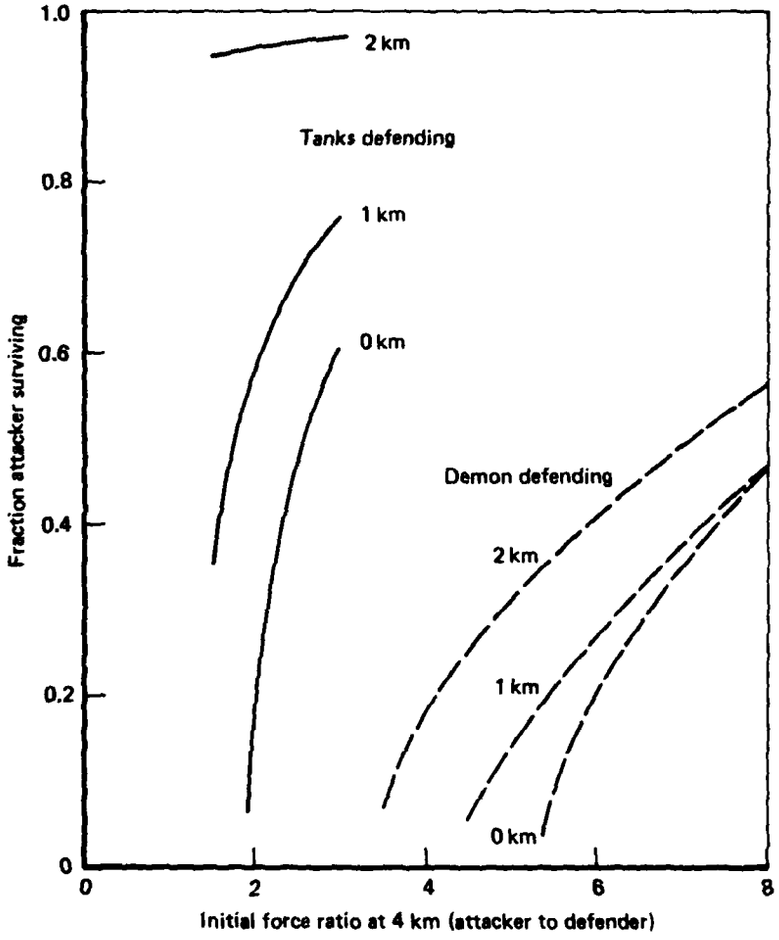

Fig. 29 — Attacker tanks surviving

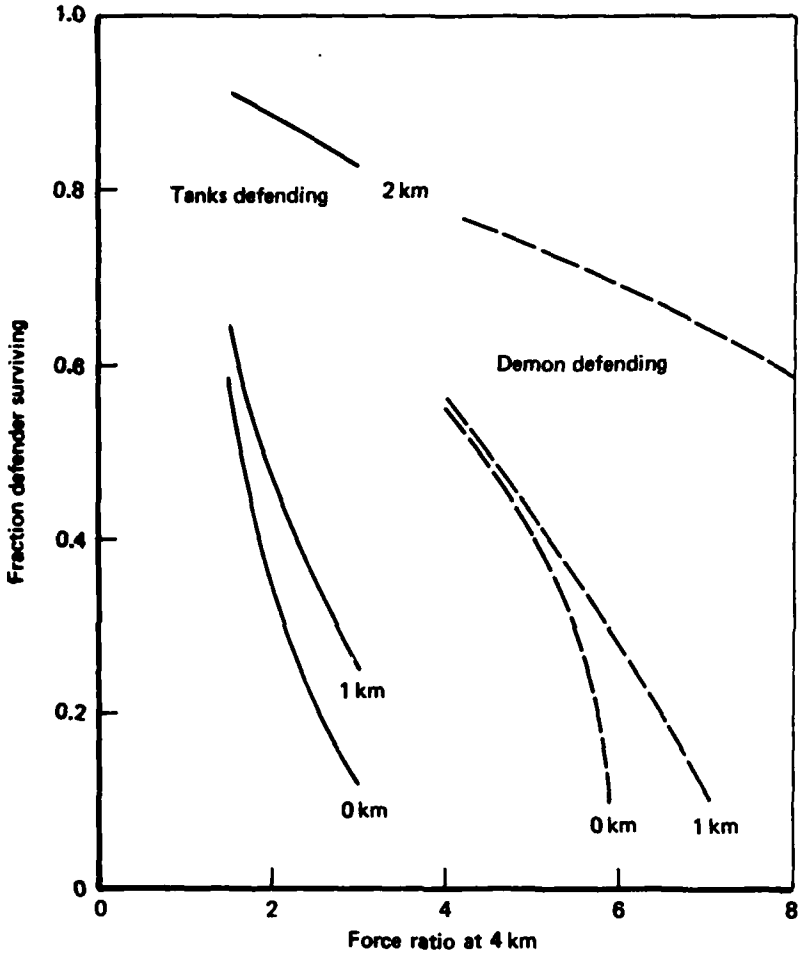

Fig. 30— Defender surviving

km. Attacker tanks firing against Demon produce about equal numbers of kills between 4 and 2 km as they do between 2 km and 1.0 km (Fig. 30).

Figures 29 and 30 also summarize the dynamic force ratios at various stages of the attack and reinforce previous conclusions. For the tank-to-tank case, the final force ratio decreases and is favorable to the defender only at initial force ratios of less than about 2:1, while for Demons on defense the final force ratio decreases at force ratios of less that about 5:1.

The implications of these results are to utilize Demons at the longer ranges and add more Demons or increase the Demon fire rates to increase the size of the attack that can be stopped. If a mix of Demons and tanks is employed on defense, the defending tanks should only reveal themselves in the final closing phases of the attack and then only when the objective is to retain the position.

IV. DEDUCTIONS, ISSUES, AND FUTURE WORK

Assuming Demon lives up to the rather modest capabilities postulated (probability of detecting a moving tank target to 4 km = 0.75 and probabililty of stopping a tank target at 4 km = 0.45), the enemy can be expected to use some operational and, perhaps, technological countermeasures.

Operational countermeasures include (1) more careful selection of advance routes to limit attrition at longer ranges, e.g., 4 km into 2 km; (2) using dismounted infantry for assault of defense positions rather than attempting to make final assaults with armor and mounted infantry; or (3) using artillery and/or other area coverage munitions to reduce Demon forces. Any or all of these operational countermeasures cause delays for the attacker. Also they can be countered by the defender. For example, the defense can use Demons farther forward of tank positions to extract even longer range attrition and cover cross country routes. Artillery and/or other area coverage weapons could be used to counter dismounted infantry assaults. However, Demon should have some protection against artillery round fragments, accepting losses from only nearby or direct hits.

Technological countermeasures are clearly an option. If Demon uses millimeter-wave radar, the enemy can be expected to use transmitter detection and location equipment. This is, however, only a partial solution. Since tank guns have aim problems at long ranges, other weapon systems would have to be used to take advantage of detection-location techniques. The possibility of Demon location detection--

presumably accurate even with frequency jumping radars, etc.--suggests that Demon transmitters may need a variable duty cycle. Perhaps they could scan an area for 3-5 sec, automatically detect a moving target, react, and then look again to limit enemy detection and antiradiation missile responses. If Demon has a launch and leave capability, the radar need not be on after missile launch to fire. Direct fires could be foiled if the launcher and radar were hidden (behind a berm or hill, for example) or moved frequently. Demon-like weapons could successfully attack Demons. Compressed air launch or any non-heat-dissipating launch mechanism would help to reduce IR detection. Note that this also argues for remote or battery power supply to keep signatures down. If Demon is stationary, enemy weapons which depend on MTI radar would have problems.

The possible effects of various operational and technological countermeasures in terms of the related sensitivities of Demon capabilities should be examined to determine appropriate Demon design envelopes.

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